RESEARCH PRIORITIES FOR FY2001

The Research Priorities presented here were reviewed and modified from the current FY2000 priorities in accordance with the Earthquake Hazards Program Five Year Science Plan (U.S.G.S. Open-File Report 98-143). This plan describes three major program elements that are the focus of the U. S. Geological Survey's Earthquake Hazards Program (USGS-ERP). These elements are: I. Products for Earthquake Loss Reduction; II. Earthquake Information; and III. Research on Earthquake Occurrence and Effects. The ERP has identified the first and third elements as suitable for research supported through an external grants program. Each of these elements is cast in six regional or topical areas as listed below:

- Southern California (SC): From the Carrizo Plain south to the international border with Mexico
- Northern California (NC): From Cape Mendocino south to Parkfield, including the San Francisco Bay Area
- Pacific Northwest (PN): Washington, Oregon, and California north of Cape Mendocino (Cascadia) and Alaska
- Central United States (CU): The New Madrid seismic zone and surrounding areas
- National/International (NI): All earthquake-prone geographic areas not included in the above four regions
- Processes, Laboratory, and Theoretical (PT): Basic and applied research that has potential for reducing earthquake hazard in many geographic areas.

A peer panel of experts in each of these regional or topical areas reviews proposals under both elements. Proposals submitted in response to this solicitation must indicate the program elements and regional or topical area the proposed research addresses.

The USGS-EHP places high priority on investigations in four areas where large populations are exposed to significant seismic risk: Southern California, Northern California, the Pacific Northwest, and the Central United States. Studies in other, earthquake-prone regions of the United States should be directed to the National-International panel. Foreign research proposed must be applicable to domestic issues. Proposals for theoretical or laboratory work on earthquake processes should be directed to the PT panel. **All proposed work should indicate how the expected results can be applied to reducing losses from earthquakes in the US.**

Pages 9-10 of this announcement describe the process of proposal evaluation by each of the above peer review panels.

Regional and topical coordinators may be able to assist applicants by describing related work within the USGS, identifying existing relevant data sets, and helping applicants establish contacts with USGS researchers working in similar areas. Coordinators are listed on the ERP internet page, http://erp-web.er.usgs.gov.

As mentioned above, the EHP Five Year Science Plan describes the three major program elements that are the focus of the USGS-EHP; these elements were identified through USGS and independent external review. Two of these three elements are identified by the EHP as being applicable for research done through the external grants program and are described below. Following each element's description is a list of Priority Tasks for each geographical and topical area. We emphasize that this listing of Priority Tasks is not intended to discourage submission of proposals to accomplish other important tasks.

ELEMENT I. Products for Earthquake Loss Reduction
The USGS-EHP produces and demonstrates products that enable the public and private sectors to assess earthquake hazards and implement effective mitigation strategies. A key contribution of the USGS earthquake program is the series of national probabilistic seismic shaking hazard maps that are produced and updated periodically with new and refined information. These maps have grown out of the research efforts and systematically quantify the seismic shaking hazard for our nation. They are used as input for policy decisions on building codes and land use. In support of these maps, the USGS will produce accessible GIS databases of active earthquake source zones with up-to-date information on slip rates and recurrence intervals.
For urban areas at high risk from earthquakes, the USGS plans maps and other products to quantify shaking amplification and susceptibility to liquefaction and landslides. The USGS is focussing on three of these urban areas that are at risk from earthquakes: The Seattle/Puget Sound Region; the San Francisco Bay Area; and the Memphis Tennessee region. For these three areas the USGS requires large-scale geologic and geotechnical mapping to better characterize and define the seismic ground shaking hazards at scales useful to engineers and planners. These products will be incorporated into the Federal Emergency Management Agency's (FEMA) loss reduction efforts. In response to requests from city planners, earthquake scenarios of large urban earthquakes will be developed for public planning.

Tasks that need to be addressed in each region are given below:

In Southern California
- Compile seismic, geotechnical and geologic data from both surface and from drill-hole observations necessary to predict regional ground motions and develop models to estimate variations in expected ground motions, accounting for bedrock excitation, site effects, duration of shaking, and soil-structure interaction.
- Develop models to explain and quantify the effects of fault interaction with particular emphasis on the earthquake cycle in Southern California.
- Develop and verify methods for calculating time histories of strong ground motion. Produce synthetic time histories for scenario earthquakes in the Los Angeles and San Bernardino regions.
- Develop credible planning earthquake scenarios for Los Angeles and San Bernardino regions.
- Collaborate with the USGS and TriNet working groups to enhance tools needed for accurate, rapid portrayal of shaking; develop ground motion attenuation relations pertinent to ShakeMap ground motion parameters, including and rupture directivity.
- Compile and provide access to geotechnical, structures, and seismic databases that will provide useful information for mitigation and emergency response efforts.

In Northern California
- Develop models to explain and quantify the effects of fault interaction with particular emphasis on the earthquake cycle in the San Francisco Bay Area.
- Maintain and improve existing fault monitoring networks with downhole strain, geodetic, and creep measurements in northern California.
- Develop geotechnical information to model the location and amount of permanent ground deformation expected from Bay Area scenario earthquakes.

- The USGS is preparing large-scale seismic hazard assessments for the San Francisco Bay Area. Projects that will directly affect the quality and usefulness of such assessments are encouraged. In particular, studies are especially needed that:
  - map the geology on a 1:24,000 scale providing the basic input data for derivative liquefaction susceptibility and site-response maps,
  - focus on the identification of recently active faults and their slip rates
  - quantify relations to extrapolate shear velocities and attenuation from other types of sub-surface data,
  - Collaborate with the USGS, working groups, professional organizations, and regional consortia to develop products useful for local outreach and formation of partnerships with likely hazards map users.
- Compile and provide access to geotechnical databases that will provide useful data for developing mitigation techniques and planning emergency response efforts.

In the Central United States

- The USGS is preparing seismic hazard maps for the Memphis metropolitan area. Projects that will directly affect the quality and usefulness of such maps are encouraged. In particular, studies are especially needed that:
  - map the geology on a 1:24000 scale providing the basic input data for derivative liquefaction susceptibility and ground motion maps,
  - characterize the attenuation properties of the propagation paths between seismic sources and the surface in the Mississippi embayment,
  - develop relationships between lithologies local to the Mississippi Embayment and seismic wave velocities,
  - help determine site amplification factors appropriate for Mississippi embayment near-surface structure,
  - collaborate with the USGS, working groups, professional organizations, and regional consortia to develop products useful for local outreach and formation of partnerships with likely hazard map users,
  - develop models of non-linear ground motions appropriate to Mississippi embayment sediments, compile a series of reference sediment columns appropriate for use in ground motion and ground failure calculations,
  - evaluate the affects of the Mississippi embayment structure (upper few km) on wave propagation (i.e., the extent to which it acts as a wave-guide, reflects energy at its boundaries, etc.),
  - assess of the affects of fault finiteness on high-frequency radiation.

In the Pacific Northwest

- Model the effect of the sedimentary basins in the Portland and Puget Sound metropolitan areas on strong ground motions expected from subduction-zone, crustal, and Benioff zone earthquakes.
- Develop models to explain the interaction between the subducting Juan de Fuca plate and North America plate in the Pacific Northwest.
- The USGS is preparing seismic hazard maps for the Seattle area. Projects that will directly affect the quality and usefulness of these maps are encouraged. In particular, we are interested in studies that:
  - improve understanding of regional attenuation relations, including examining differences between Benioff zone and crustal relations for paths form source zones to urban centers.
  - develop method of using regional(western Oregon and Washington) crustal deformation rates to estimate slop rates for large crustal fault systems in the Puget lowlands.
  - collaborate with the USGS, professional organizations and regional consortia to develop means to improve understanding of current earthquake hazard issues targeted to specific user groups within Seattle (e.g., small businesses, trade associations) to the National Seismic System

In Other Regions of the United States and International

- Compile new and upgrade existing data that provide input information for seismic hazard maps.

Examples of the types of data include: moment-magnitude-based earthquake catalogs from regional network data and historical information for earthquakes of magnitude 4 and greater in western North America and magnitude 3 and greater in central and eastern North America, information on the location and characteristics of active faults, and regional or local information on attenuation properties or ground-motion amplification that would impact hazard assessments.

- Develop improved regionally specific ground-motion attenuation relations in the central and eastern USA that include the effects of source finiteness.
- Determine recurrence intervals, slip rates, and segmentation characteristics and uncertainties of poorly studied active faults that directly affect the hazard in highly populated urban areas.
- In consultation with USGS geodesists studying crustal deformation, develop a prototype geodetic database designed to quantify neotectonic deformation at a national scale.

In Processes, Theoretical, and Laboratory Studies

- Develop methodology for modeling 3-D earthquake wave propagation in sedimentary basins. Test the methodology in well-characterized basins, with particular emphasis on the Santa Clara and San Bernardino basins in California.
- Develop applications of GIS technologies to large-scale earthquake hazard assessments.

ELEMENT II. Research on Earthquake Occurrence and Effects

The USGS pursues earthquake research to understand earthquake occurrence and effects for the purpose of developing and improving hazard assessment methods and loss reduction methodologies.

Because all of the current USGS products of the earthquake program have developed from its research efforts, the USGS will continue a major focus on understanding earthquake occurrence in space and time. The physical conditions for earthquake rupture initiation and growth need to be elucidated with field measurements in fault zones and modeling of seismicity, crustal deformation, and other earth science data. Additional areas of interest include earthquake triggering, fault interactions, and the role of aseismic slip in relieving the buildup of crustal strain. Understanding in these areas will lead to better estimates of the long-term seismic hazards to our country. To address short-term seismic hazard evaluations, work on earthquake statistics and evaluations of stress fields associated with large earthquakes may facilitate estimates of likelihood and location of future earthquakes. Reducing future earthquake losses depends on an understanding of the damaging effects of earthquakes. Using data from our regional seismic networks, research in this area will address how complexities in the earthquake source, wave propagation effects, and near-surface geological deposits control the strong shaking. Studies will also investigate the factors that govern susceptibility to ground failure from landslides, liquefaction, and lateral spreading.

In Southern California

Investigate Quaternary faulting and develop regional models of active deformation and fault interaction.

- Use waveform data to determine earthquake source parameters and crustal structure, and further develop and validate 2- and 3-D Earth models for Southern California..
- Develop and verify methods for calculating time histories of strong ground motion.
- Characterize the behavior of active faults segments and clarify differences between seismic and aseismic processes. The Los Angeles, Ventura, and San Bernardino basins are of particular interest.
- Utilize data from recent foreign earthquakes for the investigation of earthquake source, ground motions, and other issues relevant to hazards in southern California.

- Conduct geodetic and modeling studies in the Los Angeles, Ventura, and San Bernardino basins. Evaluate the consistency between geodetic and seismic slip rates.

In Northern California

- Determine paleoearthquake chronologies and refine slip-rate and recurrence estimates and evaluate segmentation models for major faults of the San Andreas system, in the following priority: Hayward, San Andreas, Calaveras, Concord-Green Valley, Rodgers Creek, Greenville, San Gregorio and Maacama faults.
- Use waveform data to define the 3-dimensional structure of the crust.
- Characterize the extent, structure, geometry, and stratigraphy of basins in the San Francisco Bay region, with particular emphasis on the Santa Clara valley and Livermore basin.
- Determine the geometry, location, and rate of deformation on fold and thrust-fault structures in the San Francisco Bay Area and quantify the rates of compressional deformation associated with surface and blind thrust faults.

In the Central United States

- In support of ongoing seismic hazard mapping in the Memphis metropolitan area and other areas:
    - provide basic geotechnical data and develop and apply analysis techniques to infer ground motions (magnitudes) from paleoearthquakes,
    - locate and characterize seismogenic faults in the New Madrid seismic zone, particularly near Memphis,
    - develop theoretical models of fault loading in low strain-rate environments,
    - develop testable methods of relating ground motions to intensity observations,
    - better constrain the southern and northern termini of the New Madrid fault zone and seismogenic potential of Reelfoot rift bounding faults,

- Evaluate GPS monument stability and noise levels in unconsolidated sediments, like those of the Mississippi Valley region.
- Analyze all available geodetic data from the NMSZ.
- Conduct investigations to determine spatial and temporal characteristics of prehistoric earthquakes. Expand the regional coverage of such investigations beyond the area of current microseismicity in the northern Mississippi embayment to locate other possible source zones.

In the Pacific Northwest

- Conduct field investigations for evidence of ground shaking or displacement associated with the possibility of late Holocene earthquakes throughout the Puget Sound region.
- Conduct field investigations for evidence of ground shaking or displacement associated with the possibility of late Holocene earthquakes in the greater Portland area.
- Develop models that examine the effect of the long durations expected from subduction zone events on predicted ground motions.
- Conduct field investigations and develop models using existing observations necessary to understand crustal deformation in Cascadia. Proposed measurements in Cascadia must be integrated into a single a regional crustal deformation strategy.
- Identify and characterize active tectonic structures in the Portland and/or Seattle metropolitan area.
- Conduct field investigations for evidence of late Holocene ground shaking or displacement in the greater Anchorage area associated with past subduction zone, crustal, and Benioff zone events.

In Other Regions of the United States and International

- Develop regionally specific ground-motion time histories and validate against observed ground-motion records. Devise methods of making these time histories available to the earthquake hazard community.
- Conduct Quaternary geologic, geomorphic, and paleoseismic investigations (including paleoliquefaction studies) and companion geophysical surveys to determine the spatial and temporal distribution of prehistoric earthquakes in earthquake-prone parts of the U.S. and U.S. Territories in the Caribbean region.

- Use inferred ground-motion from detailed damage data to determine which ground-motion parameters are correlated best with building performance in order to determine alternative parameters for the National Seismic Hazard maps.

In Processes, Theoretical, and Laboratory Studies

- Conduct laboratory and field studies of active and exhumed fault zones to gain knowledge of how stresses, fluid pressure, temperature, pore fluid chemistry, and internal fault zone structures affect earthquake processes.
- Collect and interpret data documenting aseismic fault slip processes.
- Develop and test guidelines for interpreting fault stepovers, geometric irregularities and material property contrasts as delimiters of earthquake source zones in a range of tectonic environments.
- Implement conceptual and theoretical models of the earthquake process that can simulate both quasistatic and spontaneous seismic slip on major strike-slip or dip-slip faults at a regional scale. Test simulations using field and laboratory data and identify additional data that would constrain simulation parameters.
- Formulate and test hypotheses on the initiation, propagation, and arrest of seismic rupture and their implications for earthquake source effects on strong ground motion.
- Determine the physical mechanisms linking foreshocks to mainshocks, with long-term goals of more accurately calculating foreshock probabilities and developing public warning capability based on the identification of foreshocks.
- Improve estimates of long-term earthquake probabilities, especially by quantifying and determining physical reasons for the variability of recurrence times on identified fault segments.
- Investigate whether high strain rates measured using geodetic techniques such as GPS indicate enhanced potential for damaging earthquakes in any part of the United States.
- Determine the mechanisms by which significant earthquakes modify background seismicity in their immediate vicinities and trigger earthquakes at large distances, with the goal of issuing rapid public assessments of earthquake threat modification following major earthquakes.
- Test assumptions about earthquake recurrence used to construct the National Probabilistic Hazard Maps.
- Collect field data and conduct laboratory experiments to improve our fundamental understanding of the processes leading to liquefaction, lateral spreading, and slope failure during earthquakes.
- Analyze existing data to identify the parameters of ground motion that control damage to structures, and investigate soil structure interaction.
- Continue the focused fault-monitoring effort at Parkfield, California.
- Monitor deformation, fluid pressure, or electrical and magnetic fields to attempt recording of signals that could be earthquake precursors, and conduct field, laboratory, and theoretical investigations into the mechanisms of such precursors.